COMPOSITION TO ENHANCE PERMEATION OF TOPICAL SKIN AGENTS

1. Field of the Invention

This invention relates to compositions and methods for enhancing the penetration of topical skin agents into the epidermal and dermal layers of the skin. More particularly, it relates to compositions containing at least one active ingredient, a skin conditioner or nutrient that can be enhanced and regulated in penetrating the skin with a polymeric emulsifier, and, alternatively, a sugar or a polyoxyethylene alcohol.

2. Background of the Invention

In the field of therapeutic skin care, topical agents are often applied to the skin. In order to ensure their therapeutic activity, these agents must be applied onto the skin and be allowed to penetrate the epidermis and dermis. Although conceptually simple, this has often proven to be a formidable task, because of the skin's intended function as a well-designed barrier to foreign matter from the ambient environment. The outermost layer of the skin is composed of the *stratum corneum*, or "horny layer", containing several layers of dead, keratinized and flattened skin cells. This layer is extremely difficult to penetrate. It contains approximately 15% water, 70% protein and 15% lipid. The predominant protein is keratin. In the stratum corneum, a cornified envelope forms around the keratin resulting in corneocytes. Between these corneocytes are the lipids that bind the corneocytes together. From this structure, two routes become available for active ingredients to enter the skin.

Hydrophobic active ingredient are generally expected to be more apt to penetrate the skin through the intercellular lipid spaces. Hydrophilic actives, however, are expected to penetrate the stratum corneum through a transcellular pathway, i.e., through the corneocyte. However, even though there are two routes of entry, most topical actives still have difficulty penetrating the stratum corneum. Furthermore, if a composition contains actives that are hydrophobic as well as hydrophilic, the known

penetration enhancing agents for one type of active may not serve to assist the penetration of the other and, in fact, may be expected to inhibit such penetration.

Another problem arises when providing formulations that enhance the penetration of topical agents: increasing the amount of active agent in the skin often produces excessive skin irritation. This, of course, is extremely undesirable, particularly for patients who are suffering inflammatory skin diseases or conditions.

Therefore, an object of this invention is to provide a delivery system that enhances the skin penetration of topically active agents.

An additional object of this invention is to provide that such delivery system not only allows for enhancing the penetration of the active but regulating delivery of the topical active as well.

Yet another object of this invention is to provide a delivery system having a low irritation profile while enhancing the skin penetration of such active ingredients.

A novel composition that enhances the penetration of hydrophilic and/or hydrophobic topically active compounds through the outermost layer of the skin would be advantageous for delivering therapeutic agents to the skin. Surprisingly, we have found novel compositions that enhance and regulate the penetration of topical active ingredients. Moreover, the compositions of this invention are unexpectedly mild and non-irritating to the skin despite the increased penetration of topical active agents.

Summary of the Invention

The novel compositions of this invention may enhance the penetration of either hydrophobic or hydrophilic topical active agents. The compositions of this invention further provide a method of enhancing the penetration of both hydrophobic and hydrophilic agents, as well as a method to regulate the penetration of such agents. The novel compositions of this invention that enhance the penetration of hydrophobic active agents contains at least one hydrophobic or hydrophilic active agent, and a polymeric emulsifier. This composition may more preferably contain a sugar.

The novel compositions of this invention that enhance the penetration of hydrophilic active agents may also contain at least one hydrophilic penetration-enhancing agent such as a polyoxyethylene alcohol. Additionally, other components that aid in enhancing and regulating the penetration of such topical active agent may be added to the compositions of this invention such as the following: a polymeric emulsifier, a sugar and a polyoxyethylene alcohol. Novel compositions of this invention that possess the property of enhanced penetration that contain a hydrophobic active agent may also contain at least one hydrophilic penetration-enhancing agent such as a sugar.

The novel compositions of this invention that provide the regulation of delivery of hydrophilic and hydrophobic active agents in the same composition contain at least one hydrophobic active agent; at least one hydrophilic active agent, such hydrophilic active agent optionally being a sugar; a sugar ; and polyoxyethylene alcohol.

Polymeric emulsifiers, particularly those which have been hydrophobically-modified, are useful in the compositions of this invention. In both pharmaceutical and cosmetic compositions, lotions and creams have been used as popular delivery vehicles for applying topical actives. Emulsions are two-phase systems that contain two immiscible liquids, typically oil and water. In order to stabilize oil in water, ionic or non-ionic surfactants may be used to reduce interfacial surface tensions creating oil droplets dispersed in water. Unlike traditional emulsifiers, polymeric emulsifiers operate by creating gels around the oil droplets. When these droplets come near each other, they are repelled by the gel layers. Preferably, a nonionic polymeric emulsifier, more preferably a hydrophilic cross-polymer which has been hydrophobically modified and most preferably, a hydrophobically-modified polyacrylic acid emulsifier having from about 10 to about 30 carbon atoms is used in the products and compositions of this invention. Most preferably, the polymeric emulsifier should be Pemulen*, an acrylate/C10-30 alkyl acrylate crosspolymer commercially available from B.F. Goodrich Specialty Chemicals of Cleveland, Ohio. Surprisingly, delivery systems containing lipophilic topical active ingredients formulated in the compositions of this invention in

conjunction with Pemulen* provided enhanced penetration of the lipophilic topical active ingredient. Preferably, the polymeric emulsifier should be present in the compositions of this invention an amount of from about 0.01 to about 20% by weight of the composition. More preferably, they should be present in an amount of from about 0.1 to about 5 weight percent of the composition. Most preferably, they should be present in an amount of from about 0.1 to about 1 weight percent of the composition.

Sugars have also been commonly used in pharmaceutical and cosmetic compositions as humectants. Surprisingly, in the compositions of this invention, sugars that were incorporated into such compositions for the purpose of improving the compositions' skin feel characteristics, served to enhance the penetration of hydrophobic topical active ingredients. We also found, surprisingly, that the combination of hydrophobically-modified polymeric emulsifiers and sugars enhanced the penetration of the hydrophobic active ingredients together to a greater degree than either would if used separately. Moreover, sugars that assist in enhancing penetration may be hydrophilic topically active agents themselves. Sugars that may be useful in the compositions of this invention include, for example, ascorbic acid-2-glucoside, oligosaccharides such as lactose and melibiose and the like. Preferably, the sugar should be present in the compositions of this invention an amount of from about 0.01 to about 20% by weight of the composition. More preferably, they should be present in an amount of from about 0.1 to about 10 weight percent of the composition. Most preferably, they should be present in an amount of from about 0.1 to about 7 weight percent of the composition.

In order to enhance the penetration of hydrophilic topical actives, a polyoxyalkylene alcohol may be incorporated into the compositions of this invention. More preferably, a polyoxyethylene alcohol may be incorporated into the compositions of this invention. More preferably, such alcohols as steareth-10-20 and the like may be incorporated into the compositions of this invention. Preferably, the polyoxyalkylene alcohol should be present in the compositions of this invention an amount of from

about 0.01 to about 20% by weight of the composition. More preferably, they should be present in an amount of from about 0.01 to about 5 weight percent of the composition. Most preferably, they should be present in an amount of from about 0.01 to about 2 weight percent of the composition.

In a system that contains both the hydrophobically modified acrylic acid, sugar and polyoxyethylene alcohol, unexpectedly, the compositions not only increase permeation of the topical active ingredients, but can be used to regulate the penetration of the active ingredients as well. For example, by changing the ratios of the ingredients, either hydrophobic or hydrophilic active agent penetration may be up- or down-regulated in order to enhance the therapeutic benefits of the formulations of this invention. By balancing the proportions of the elements of the compositions of the invention, proper concentrations of topical actives could be delivered, depending upon the type of benefit desired. For example, a retinoid such as retinol may be utilized in a composition to combat wrinkles and prevent photodamage while ascorbic acid-2-glucoside may be utilized for the purpose of promoting even skin tone or preventing sun-induced erythema. Therefore, under some circumstances, the retinol benefit may be up-regulated in order to provide treatment of wrinkles while the penetration into the skin of another undesirable hydrophilic component that functions as a formulation excipient (e.g. disodium EDTA that causes irritation) may be down-regulated to achieve maximum benefit. Surprisingly, although increased penetration of actives occurred, irritation was found to be minimal.

Thus, for example, in a composition wherein a hydrophobic active ingredient is desired to be delivered to a great extent into the skin and the penetration of an irritating hydrophilic excipient is desired to be down-regulated, the ratio of the hydrophobically modified acrylic acid, sugar and polyoxyethylene alcohol present in such a composition should be from about 0.001 to about 1000. The ratio of the hydrophobically modified acrylic acid to the sugar should be from about 0.001 to about 1000. The ratio of the hydrophobically modified acrylic acid to the polyoxyalkylene alcohol should be from about 0.001 to about 1000. The ratio of the sugar to the polyoxyalkylene should be

from about 0.001 to about 1000. More preferably, the ratios should be as follows: the ratio of the hydrophobically modified acrylic acid, sugar and polyoxyethylene alcohol present in such a composition should be from about 0.1 to about 10. The ratio of the hydrophobically modified acrylic acid to the sugar should be from about 0.1 to about 10. The ratio of the hydrophobically modified acrylic acid to the polyoxyalkylene alcohol should be from about 0.1 to about 10. The ratio of the sugar to the polyoxyalkylene should be from about 0.1 to about 10.

The compositions of this invention assist in enhancing skin penetration of hydrophobic, also known as lipophilic, compounds. More particularly, hydrophobic vitamins such as retinol and tocopherol and the like may be incorporated into the compositions of this invention as active agents. To maximize the delivery of a lipophilic agent, the composition contains at least one topical active agent and a hydrophilic polymer that has been hydrophobically modified. The use of a sugar in combination with the hydrophobically-modified hydrophilic polymer unexpectedly further increases the delivery of the active agent.

The addition of polyoxyalkylene alcohol should increase the penetration and regulation of any hydrophilic ingredients in the composition. Despite the enhanced penetration of the topical agents, the composition is surprisingly non-irritating to the skin.

Any topical dosage form known to those of ordinary skill in the art, including, but not limited to, lotions, gels, sprays, aerosols and mousses.

The compositions of this invention should preferably contain:

(a) a topically active amount of a pharmaceutical or cosmetic active ingredient;

(b) from about 0.01% to about 20% of a non-ionic polymeric emulsifier;

(c) optionally, from about 0.01% to about 20% of a sugar; and

(d) optionally, from about 0.01% to about 20% of a polyoxyethylene alcohol.

Detailed Description of the Preferred Embodiments

This invention provides compositions and methods to enhance and regulate the delivery of topical agents. The compositions of this invention comprises a pharmaceutical agent or cosmetic active ingredient, hydrophilic polymer that has been hydrophobically modified, optionally a sugar, optionally, polyoxyalkylene alcohol or any combination thereof. The pharmaceutical active includes any drug, hydrophobic or hydrophilic in nature, that would be appropriate for topical use. The cosmetic active includes any ingredient appropriate for cosmetics, nutrients or skin conditioners. These compositions are also non-irritating to the skin.

The pharmaceutical actives that can be used in the compositions of this invention, but not limited to, are antimicrobials, allergy inhibitors, anti-acne, analgesics, antitussives, antipruritics, anesthetics, antihistamines, anti-infective agents, inflammation inhibitors, anti-emetics, anticholinergics, vasoconstrictors, vasodilators, and wound healing promoters and the like.

The cosmetic active ingredients that can be used in the compositions of this invention, but not limited to, are vitamins (e.g., vitamin B complex; including thiamine, nicotinic acid, biotin, pantothenic acid, choline, riboflavin, vitamin B6, vitamin B12, pyridoxine, inositol, carnitine; vitamins A, C, D, E, K and their derivatives, pro-vitamins), amino acids and their derivatives, herbal extracts, retinoids, flavonoids, anti-oxidants, anti-inflammatory, skin conditioners, skin lighteners, chelating agents, cell turnover enhancers, coloring agents, fragrances, pigments and sunscreens and the like.

Preferably, the hydrophobically-modified hydrophilic polymeric emulsifiers used in the compositions of this invention are hydrophobically modified acrylic acids. Such as akylacrylates and the esters. The akyl chain lengths ranges from C2-C30.

Sugars that can be used in the compositions of this invention may include, but are not limited to, glucose, oligosaccharides, more particularly disaccharides such as fructose, melibiose, xylose, sucrose, arbutin, maltose, glucosides glycosides and derivatives thereof and the like. Sugars function in the compositions of this invention to enhance penetration of both hydrophobic and hydrophilic active ingredients.

Polyoxyethylene alcohols function in the compositions of this invention to enhance the penetration of hydrophilic active ingredients and can be used in the compositions of this invention. Such polyoxyethylene alcohols include, but are not limited to: ceteths, laureths, myreths, oleths, steareths and trideths. One particularly preferred example is steareth-10 or Brij 76 made by ICI Surfactants of Delaware, USA.

The delivery system and active ingredients are incorporated in a pharmaceutically or cosmetically acceptable vehicle. Preferably, the pH of the compositions of this invention should be from about 5 to about 9, more preferably from about 5 to about 7.

Of course, topical skin care agents known to those of ordinary skill in the art may be incorporated into the compositions of this invention, including mineral oils, animal oils, vegetable oils and silicones have all been used in cosmetic creams and lotions of the emulsion type. In addition to such oils, other emollients and surface active agents have been incorporated in the emulsions, including glyceryl trioleate, acetylated sucrose distearate, sorbitan trioleate, polyoxyethylene (1) monostearate, glycerol monooleate, sucrose distearate, polyethylene glycol (50) monostearate, octylphenoxypoly (ethyleneoxy) ethanol, deacylerin penta-isostearate, sorbitan sesquioleate, hydroxylated lanolin, lanolin, triglyceryl diisostearate, polyoxyethylene (2) oleyl ether, calcium stearoyl-2-lactylate, methyl glucoside sesquistearate, sorbitan monopalmitate, methoxy polyethylene glycol-22/dodecyl glycol copolymer (Elfacos E200), polyethylene glycol-45/dodecyl glycol copolymer (Elfacos ST99), polyethylene glycol 400 distearate and glyceryl stearate; alcohols, such as cetyl alcohol and lanolin alcohol; myristates, such as isopropyl myristate; cetyl palmitate; cholesterol; stearic acid; propylene glycol; glycerine, sorbitol and the like. Thickeners such as natural gums and synthetic polymers, as well as preservatives such as methylparaben, butyl paraben, propylparaben and phenyoxyethanol, coloring agents and fragrances also are commonly included in such compositions. Other active ingredients such as sunscreen materials and antimicrobial materials may be utilized in the compositions of the present invention provided that they are physically and chemically compatible with the other components of the compositions.

The following examples illustrate, but do not serve to limit the scope of the compositions and methods of this invention.

Examples

Example 1: Determination of Penetration and Regulation of Topical Agents

Five formulations were made containing the following ingredients:

Formulation A (Comparison formulation):

Ingredient	Weight Percent
Water	73.86%
Thickeners	1.35%
Chelating agent	0.10%
Panthenol	0.50%
Glycerine	3.00%
Whitening agent	3.00%
PH adjustor	0.05%
C12-15 alkyl benzoate	4.00%
Octyl hydroxy stearate	1.00%
Dimethicone	1.00%
Cetyl alcohol	2.50%
Cetearyl glucoside	1.40%
Tocopheryl acetate and Tocopherol	0.55%
Sunscreen	4.00%
Preservative	1.25%
Stabilizers	1.10%
Retinol	0.04%

The following formulations B, C, D and E were made as set forth below:

Formulation B:

Ingredient	Weight Percent

Water	78.04%
Glycerin	3.00%
D panthenol	0.50%
Disodium EDTA	0.10%
Preservative	0.73%
Preservative	0.35%
Acrylates/C10-30Alkyl Acrylate Cross-Polymer	0.25%
Carbomer	0.40%
Ascorbic Acid	0.01%
Dibutylhydroxy-toluene	0.10%
Cetyl Alcohol	2.00%
C_{12}-$_{15}$ alkyl benzoate	4.00%
Octyl hydroxy stearate	1.00%
Dimethicone	1.00%
Di-alpha tocopheryl acetate	0.50%
Octyl methoxy-cinnamate	4.00%
Propyl paraben	0.17%
Na hydroxide (10%)	2.60%
Retinol 50c	0.20%
Tocopherol	0.05%
Thea Sinesis Extract	1.00%

Formulation C:

Ingredeint	Weight Percent
Water	73.39%
Glycerin	3.00%

D panthenol	0.50%
Disodium EDTA	0.10%
Ascorbic Acid-2G	2.00%
Phenoxyethanol	0.73%
Methyl paraben	0.35%
Xanthan gum	0.20%
Hydroxyethylcellulose	1.15%
Ascorbic Acid	0.01%
Dibutylhydroxytoluene	0.10%
Cetearyl glucoside	1.40%
Cetyl Alcohol	2.00%
C_{12}-$_{15}$ alkyl benzoate	4.00%
Octyl hydroxy stearate	1.00%
Dimethicone	1.00%
Di-alphatocopheryl acetate	0.50%
Octyl methoxycinnamate	4.00%
Propyl paraben	0.17%
Na hydroxide (10%)	2.45%
Retinol 50c	0.20%
Polyacrylamide & laureth 7 & C13-C14 isoparafin	0.70%
Tocopherol	0.05%
Thea Sinesis Extract	1.00%

Formulation D:

Ingredient	Weight Percent

Water	72.82%
Glycerin	3.00%
D panthenol	0.50%
Disodium EDTA	0.10%
Preservative	0.73%
Preservative	0.35%
Acrylates/C10-30 Alkyl Acrylate Cross-Polymer	0.25%
Dimethicone	1.00%
Cetyl Alcohol	2.00%
Di-alpha tocopheryl acetate	0.50%
Octyl methoxycinnamate	4.00%
Propyl paraben	0.17%
Na hydroxide (18%)	1.50%
Retinol 50c	0.18%
Ascorbic Acid-2G	6.35%
Tocopherol	0.05%
Thea Sinesis Extract	1.00%

Formulation E:

Ingredient	Weight Percent
Water	71.59%
Glycerin	3.00%
D panthenol	0.50%
Disodium EDTA	0.10%
Ascorbic Acid-2G	2.00%

Preservative	0.73%
Preservative	0.35%
Acrylates/C_{10-30} Alkyl Acrylate Cross-Polymer	0.25%
Carbomer	0.40%
Ascorbic Acid	0.01%
Dibutylhydroxy-toluene	0.10%
Steareth-10	2.00%
Cetyl Alcohol	2.00%
C_{12-15} alkyl benzoate	4.00%
Octyl hydroxy stearate	1.00%
Dimethicone	1.00%
Di-alpha tocopheryl acetate	0.50%
Octyl methoxycinnamate	4.00%
Preservative	0.17%
Na hydroxide (10%)	5.05%
Retinol 50c	0.20%
Tocopherol	0.05%
Thea Sinesis Extract	1.00%

Formulation F:

Ingredient	Weight Percent
Water	49.484
Squalane	15.000
Glycerin	10.000
Macademia Nut Oil	7.000
Pentaerythritol Tetraoctanoate	5.000

Butylene Glycol	4.000
Petrolatum	3.000
Quaternium 18 Hectorite	2.700
Polyglyceryl-2-Diisostearate	2.000
PEG 150	1.000
Retinol	0.166
Trisodium EDTA	0.100
Ascorbic Acid	0.100
Sodium Citrate	0.100
Tocopheryl Acetate	0.100
Preservative	0.100
Preservative	0.100
Butylated Hydroxytoluene (BHT)	0.050

Formulation B was made by adding water to a beaker and overcharging the beaker with 20 grams of water. The water was then purged with argon or nitrogen gas. After 10-15 minutes, 20 grams of water was removed to check for oxygen content. If there was significant measurable oxygen in the sample, the purging was continued. Once oxygen was purged from the water, glycerin, panthenol, disodium EDTA, a first preservative and ascorbic acid were added to the beaker. The acrylates/C10-30 alkyl acrylate and carbomer were then added to the water phase. The beaker was then transferred to a vacuum close kettle homogenizer under yellow lights and any residual oxygen removed. The beaker was then heated to 70 - 75°C. A second preservative was added and mixing continued until it dissolved. The water phase was then neutralized with NaOH (10%) and the temperature held at 70 - 75°C for phasing. The remainder of the ingredients but for the Retinol, Tocopherol and Thea Sinesis Extract were combined in a separate beaker and heated to 70 - 75°C. When both phases were at the same temperature and homogenous, the oil phase was added to the water phase under vacuum and homogenized together. The beaked was then cooled slowly. Retinol was added when the temperature reached 55°C and Tocopherol and Thea Sinesis extract

added at 45°C. Formulation C was made in a similar manner, except that AA-2G was added in addition to the ascorbic acid and, after the ascorbic acid was added, the xanthan gum, hydroxyethylene and glycerin were added to the water phase. Formulation D was made similarly to Formulation B. Formulation E was made similarly to Formulation C except that Steareth 10 was added to the oil phase.

Formulation F was prepared by combining water, glycerin, PEG150, and butylene glycol in a beaker, and heating it to 75°C. At 75°C, Trisodium EDTA, ascorbic acid and sodium citrate was added. Combining squalene, Mac. Nut oil, pentaerythritol tetraoctanoate, petrolatum, quaternium 18 hectoriate, polyglyceryl-2-diisostearate, and heating the mixture to 80°C while mixing. At 80°C, parabens and BHT were added to the mixture. The water phase was added to oil phase slowly and the heated was stopped. At 50°C, Vitamin E acetate and retinol were added. The whole process should be under argon and yellow light conditions.

Experiments were conducted to determine the enhanced penetration and regulation effect of the delivery system. To determine transdermal penetration, *in vivo* skin permeation studies were conducted using non-occluded Franz diffusion cells.

Human cadaver skin section were mounted in Franz diffusion cells containing a receptor medium composed of a phosphate buffer with 0.025% butylated hydroxytoluene and 1.5% oleth-20. The receptor capacity was 5 milliliters (ml) and the cell surface area was 0.636 cm^2. A 400 μm dose of one of the following formulations was applied to the diffusion cell. After 24 hours, the surface of the cells were cleansed with a solution of methanol and ethyl acetate. The epidermis and dermis were separated, chopped and placed into vials containing a solution methanol and ethyl acetate and subjected to sonication to fragment the skin. After sonication, the skin fragments were analyzed using HPLC. Samples were taken at zero and 24-hour time-points. Penetration of active ingredient was calculated based upon a percentage of applied dose. For these studies, the penetration of a lipophilic agent (retinol and a hydrophilic agent (ascorbic acid 2-glucoside, or "AA2G") were investigated.

The formulations investigated are set forth in Table 1 below:

TABLE 1

	Composition	Ingredients	% of applied dose of retinol delivered into epidermis	Enhancement factor of retinol delivery	% of applied dose of AA-2G delivered into epidermis	Enhancement factor of AA-2G delivery
A	Conventional emulsifier (Control)	Cetearyl Glucoside	0.175%	1.00	N/A	N/A
B	Hydrophobically modified acrylic acid emulsifier	Acrylates/C10-30 alkyl acrylate crosspolymer	0.642%	3.67	N/A	N/I
C	Conventional emulsifier and sugar	Cetearyl glucoside and AA-2G	0.241%	1.38	N/A	N/A
D	Hydrophobically modified acrylic acid and sugar	Acrylates/C10-30 alkyl acrylate crosspolymer and AA-2G	1.25%	7.20	0.18%	1
E	Hydrophobically modified acrylic acid, sugar and polyoxyethylene alcohol	Acrylates/C10-30 alkyl acrylate crosspolymer, AA-2G and steareth-10	0.464	-2.70	1.016%	5.65

From the above data, it can be seen that a control formulation (Formulation A) containing only cetearyl glucoside delivered only 0.175% of the applied dose of retinol into the epidermis. Surprisingly, however, when a formulation containing hydrophobically modified acrylic acid emulsifier was used (Formulation B), the percentage of retinol delivered increased to 0.642%, a 3.669 fold increase in delivery. When AA-2G and cetearyl glucoside were placed into formulation with retinol (Formulation C), the retinol permeation surprisingly increased to 0.241%, a 1.38-fold increase over the control formulation A. Even more surprisingly, a formulation containing both hydrophobically modified acrylic acid and AA-2G (Formulation D), although an additive effect was expected, a total delivery of retinol of 1.26% or a 7.2 fold increase in retinol delivery to the epidermis.

The activity of Formulation E demonstrates that the addition of a polyoxyethylene alcohol increased the penetration from 0.18% to 1.016%, or a 5.65-fold increase of delivery of AA-2G. Surprisingly, the retinol permeation decreased from 1.25% to 0.464%, a 0.36-fold decrease. Thus, the compositions of this invention

afford a method of regulating the delivery of both hydrophilic and lipophilic ingredients.

Example 2: Low Level of Irritation Demonstrated by Compositions of This Invention

Those of ordinary skill in the art of formulating topical skin care compositions would expect an increase in skin irritation to accompany an increase in penetration of active ingredients. The compositions of this invention, however, were surprisingly non-irritating despite the improved penetration of active ingredients.

A standard test for skin irritation, called the "Modified Irritation Study" (MIS) was used to evaluate the delivery system using retinol as the topical agent. This test measures the irritation potential of compositions in human volunteers. Test formulations of this invention were applied to fifty test subjects three times per week for three weeks for a total of nine applications. An occlusive patch with 0.2 to 0.3 gm of each test composition was applied to the upper back of the human subject. The patches remained in place for an initial 24 hours. After 24 hours, the subject would remove the patch from the back. A 24-hour rest period, during which no test material was applied, followed the removal of a Monday and Wednesday patch application. A 48-hour rest period followed a Saturday patch removal.

After each rest period, the test areas were observed by a study coordinator and graded according to a scale of 0 to 4.0. Fresh test material and patches were applied to the identical test sites until nine induction patches were completed.

The nine application scores for each test site for each subject were summed to yield a total score for 21 days. A grand total score for a test sample was obtained by adding the 21-day totals for all subjects. The grand total scores were normalized against the positive control (Formulation F below) , which received a normalized score of 100 to obtain a Normalized Irritation Score. The results of these tests are set forth in Table 2 below.

TABLE 2

	Composition	Ingredients	Retinol Concentration	Total amount of retinol delivered (μg)	Normalized Irritation Score	Ratio of total retinol delivered:Normalized Irritation Score
A	Convention emulsifier (Control)	Cetearyl Glucoside	0.04%	0.21	9.88	2.1
B	Hydrophobically modified acrylic acid emulsifier	Acrylates/C10-30 alkyl acrylate crosspolymer	0.075%	1.44	68.4	2.1
C	Conventional emulsifier and sugar	Cetearyl glucoside and AA-2G	0.075%	0.54	46.5	1.2
D	Hydrophobically modified acrylic acid and sugar	Acrylates/C10-30 alkyl acrylate crosspolymer and AA-2G	0.075%	2.84	21	13.5
F	Water-in-oil emulsifier	Polyglyceryl-2-diisostearate and PEG 150	0.15%	N/A	100	N/A

An increase in retinol penetration would generally be expected to result in higher skin irritancy, or a lower ratio of Total Retinol Delivered:Normalized Irritation Score. Ratios of the amount of retinol delivered to the irritation score were calculated to compare the formulations, i.e., they represent the amount of retinol delivered per each unit of irritation. As can be seen from the data set forth in Table 2, Formulations A, B and C are all comparable to each other. Formulation is a commercial product known to be mildly irritating. From these results with respect to Formulations A, B and C, it would appear that neither the hydrophobically modified acrylic acid emulsifier nor the sugar have an effect upon irritation mitigation.

However, surprisingly, Formulation D evidences a dramatic increase in retinol delivery per unit of irritation and, therefore, is considerably less irritating than Formulations A, B and C. We would also expect that the therapeutic index of Formulation D would be greater than that of Formulations A, B or C in light of the increased amount of retinol delivered at a lower extent of irritation. We conclude that the irritation mitigation effect is unexpectedly greater in compositions containing both hydrophobically modified acrylic acid and sugar.

Delivery of hydrophilic active ingredients using the compositions of this invention and the concomitant irritation mitigation effect may be seen exemplified below in Table 3.

TABLE 3

	Composition	Ingredients	AA-2G Concentration	Total Amount AA-2G delivered (μg)	Normalized Irritation Score	Ratio of total AA-2G delivered: Normalized Irritation Score
D	Hydrophobically modified acrylic acid and sugar	Acrylates/C10-30 alkyl acrylate crosspolymer and AA-2G	2%	1.08	21	0.05
E	Hydrophobically modified acrylic acid, sugar and polyoxyethylene alcohol	Acrylates/C10-30 alkyl acrylate crosspolymer, AA-2G and steareth-10	2%	6.09	26	0.23
F	Water-in-oil emulsifier	Polyclyceryl-2-diisostearate and PEG 150	0%	N/A	100	N/A

As set forth above in Table 3, one unit of irritation results in the delivery of 0.05% AA-2G. With the addition of a polyoxyethylene alcohol, however, this number unexpectedly increases to 0.23%, meaning that more AA-2G is delivered to the skin with a lower irritation, generating a greater efficacy or therapeutic index.

Example 3: Additional Formulations of the Invention

The compositions of this invention may be made by traditional preparation method. The following Table 4 illustrates compositions of this invention which we believe would serve to enhance the delivery of hydrophobic and hydrophilic active ingredients to the epidermis and dermis of the skin with relatively low levels of irritation.

TABLE 4

Ingredient	Function	Formulation 1	Formulation 2	Formulation 3
Water	Vehicle	q.s. 100%	q.s. 100%	q.s. 100%
Glycerin	Humectant	About 0 – about 10%	About 0 – about 10%	About 0 – about 10%
Disodium EDTA	Chelator	About 0- about 1%	About 0- about 1%	About 0- about 1%
Preservative	Preservative	About 0.1 to about 2	About 0.1 to about 2	About 0.1 to about 2
Carbomer	Thickener	About 0.1 to about 1%	About 0.1 to about 1%	About 0.1 to about 1%
Pemulen	Hydrophobically modified polymer emulsifier	About 0.1 to about 1%	About 0.25%	About 0.25%
Ascorbic Acid 2-Glucoside	Sugar	0%	About 0.1% to about 5%	About 0.1% to about 5%
Butylated Hydroxytoluene	Stabilizer	About 0 to about 1%	About 0- about 1%	About 0- about 1%
Cetyl alcohol	Emollient	About 0 – about 10%	About 0 – about 10%	About 0 – about 10%
C12-15 alkyl benzoate	Emollient	About 0 – about 10%	About 0 – about 10%	About 0 – about 10%
Dimethicone	Spreading agent	About 0 to about 10%	About 0 to about 5%	About 2%
NaOH (10%)	Neutralizer	q.s. pH 5-8	q.s. pH 5-8	q.s. pH 5-8
Steareth-10	Polyoxyethylene alcohol Emulsifier	About 0 to about 5%	About 0 to about 5%	About 0 to about 5%
Sunscreen	Sunscreen	About 0 to about 10%	About 0 to about 10%	About 0 to about 10%

The compositions of this invention may be administered topically, but may also be utilized in delivery of oral and parenteral formulations.